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A MINIMUM SET OF TENTATIVE PHYSICAL STANDARDS FOR CHILDREN OF SCHOOL AGE

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Introduction

It is a function of scientific procedure in any recognized field of human endeavor, not only to secure and verify accurate information, but also to determine the significance and relationships of ascertained facts; and, for purposes of application, to standardize both the facts themselves and the methods of their use.

Education, especially since it has become so little a perquisite of the home and increasingly a duty of the state, has felt the influence of material and commercial standards, and has realized the need for similar systematized methods that the thousands of children in the public schools might be "handled" with as little waste and friction as possible. The four-fold division advocated by Commenius has been somewhat modified into the kindergarten, elementary, secondary and higher systems, a device both rational and expedient. Within each of these larger groups come the finer divisions into years, grades, terms, semesters, quarters, etc., which represent a still finer classification of students into groups of somewhat uniform accomplishment if not of ability. It must in fairness be admitted that this very standardization in education has not in all cases proved of unmixed blessing or advantage. In many individual experiences gross injustice has been done because of the inflexibility of the "system." The seriousness of this defect is being increasingly recognized, however, and steps toward its reduction, or may one venture to hope, its elimination are being considered and actually introduced.

One of the most outstanding defects in educational procedure is the same in general as the criticism levelled against standardization in industry, viz., the individual human is not given due consideration. The attendant is not a part of the machine, but a human being with hopes and fears, likes and dislikes, ambitions and regrets, who is not belted to the countershaft but whose power and motive comes from within. Nor

can the pupil be regarded as so much raw material to be crowded through the educational machine in the hope of turning out a uniform product, up to " standard." Too often the attempt is made to force the student to conform to the schedule and program of the system, whereas the democratic ideal demands that the procedure be adapted to the pupil, that each be supplied with the opportunity, methods and materials best calculated to develop individual superiority subject only to limitations in ability. This, of course, presupposes that the actual conditions, powers and needs of each pupil be ascertained.

One way in which the correction of a too fixed and wrongly based standardization is being sought is by the recognition that grouping by the age or time basis is unsatisfactory and fails to give homogeneity within any of the present age or grade groups. The direction in which greatest progress has been made is that of attempting to ascertain concerning any individual pupil about whom a question as to standing may be raised, not the chronological age, not the grade standing, but rather the mental age or ability. This is based almost exclusively upon a variety of tests of intelligence, since from the very nature of mentality, intelligence is the factor which most readily lends itself to measurement by objective standards.

Another factor concerned with adjustment of the present unsatisfactory system of grading by chronological age or length of time in school is that of physical development. This is important both in its relation to mentality and on its own account.

The relationship between physique and mentality is one upon which great differences of opinion are still held. One can find experimental data supporting practically any attitude which may be suggseted.

Thus Gilbert(58, p. 39), Bagley(6, p. 205) and West(141) found little or no, or in some cases even negative correlation between bodily development and mental ability. Burgerstein (29, p. 38) and others have criticized the above finding on the basis that mentality was judged not by the standing of the pupils but by the estimates of the teachers.

On the other hand Pearson(104, p. 106), Porter(109, p.168), Roberts(116, p. 359), MacDonald(90, p. 1027), Smedley(127), Zirkle(149, p. 9), Pyle(112, p. 39), Boas(19), DeBusk(48, p. 90), Burgerstein(29, p. 39), Crampton(44), Hogue(72), Baldwin(7, p. 82) and Arnold(2, p. 36) are among those who are satisfied that a positive and close correlation exists.

The general practice is to begin the formal education of children at some stated age—in most countries at 6 years—but factors other than and more significant than chronological

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age are beginning to be considered. To some of these, representing physical development, attention is called in the following pages.

Methods of judging success or progress in school life have been too largely based upon knowledge of subjects included in the prescribed curriculum, but with the new emphasis upon health, the condition of the pupil must be given prominent if not foremost consideration. There seems to be good evidence that at least 20% of the public school pupils are undernourished, and a larger proportion have physical defects the great majority of which are remedial. Military data indicate that many of the disqualifying defects might have been prevented or cured during school life.

It is well recognized that no single factor such as stature, weight, eruption of permanent teeth, development or organization of any muscle group, presence or absence of any secondary sexual characteristics, or in fact any known aspect of an individual may, by itself, be accepted as an infallible index of physiological development. Allowance for individual variations must be made no matter what test is being applied, but when such variations depart sufficiently from the selected standards, and especially when such variations in several tests are in the same direction from the standards, there is rather satisfactory evidence of abnormality, which may be either precocity or retardation.

Thus, should a pupil be found who shows consistently light weight for his age or height, retarded eruption of teeth, weak forearm muscles and poor coordinating power there is a concurrence of evidence of physiological subnormality, which surely deserves recognition in plans for that pupil's health and progress in school and home.

It is not assumed that each pupil's increase in any given measure will show the same regular upward movement as is indicated in the tables or standard; yet it is believed that in case of normal development each child would not differ widely from the corresponding figures. So, wherever possible from the original data, normal deviation has been computed giving the zones within which these deviations might be expected to fall. The practice is to regard any departure beyond these limits as deserving of special attention, especially should such deviation be in the direction of subnormality.

The actual time of the appearance or maturing of any change or quality in a complex organism such as the human body, is not referable to any mere temporal reckoning of the length of life, but is essentially one of development. So it is quite in accord with expectation that there cannot be any definitely

marked "time line" but rather a "time zone" within which any physiological transition may be expected to manifest itself. Boas(17, p. 187) has phrased this fact as follows:

"The range of individual differences may be indicated by those ages within the limits of which one-half of all the individuals observed attain a certain physiological development."

or, as Boas has also summarized variability:

"When we consider children of a certain age we may say that they will not all be in the same stage of development. Some will have reached a point just corresponding to their age, while others will be a little behind, and still others in advance of their age. We may assume that the difference between the stage of their development and that belonging to their exact age is due to accidental causes, so that just as many will be less developed as further developed than the average child of a particular age."

Agreeable to the principle enunciated above, the normal range of individual variations of a given age, for any single test, may be regarded as those values within which come the attainment of one-half of those observed. In practice this may be calculated by computing the median, middle value, a 50% line for the norm, the limits of normal variation will then be those values representing the middle point between this median value and the limits of the series either way, i. e., of the 25% and the 75% lines.

As in the case of mental age, certain milestones have been determined empirically as standards by which this physical progress may be judged.

Structure and function in the human body are so intimately interrelated that they should be separated only in thought and for purposes of convenience in treatment. The more important is function, but this is often difficult or impossible to test mechanically, and moreover, is frequently correlated with or based upon structures which are visible or superficial and so subject to examination, measurement, comparison, etc. In some cases structures are significant in themselves, e. g., the teeth, but in others they are but the physical basis or outward manifestation of functions which are in consequence judged and estimated on the basis of their associated structures, e. g., pubescence. On the other hand, there are certain powers or functions which may be measured as such, without prime attention to the structures involved which may condition their functional efficience, e. g., lung capacity or strength of grip.

With the primacy of function over structure definitely in mind, it is possible as a matter of classification to group the physical tests or examinations into two divisions, viz.:

1. Structural or Anatomical, those giving evidence of, e. g., size (height), mass (weight), number (teeth), significant external signs (pubic hair).

2. Functional or Physiological, those which test power directly in such particulars as, e. g., strength (forearm grip), respiratory power (lung capacity), muscular control (tapping).

Of the two foregoing groups of physical tests only a limited number are admittedly suitable for use in connection with public school education. The basis of selection of the tests advocated herein has been to include those which come within the following requirements:

1. They must be of interest and value from the standpoint of education and hygiene. This will eliminate from the accepted list many measurements which may have a high anthropological significance, e. g., cephalic index, facial angle, breadth of hand, color of eyes, etc.

2. They must be practicable from the standpoint of conditions existing or likely to exist in public school systems. This means in the main that the accepted tests be simple so as to require a minimum of skill, in taking and of expense by way of equipment, and that they do not make too serious a demand upon the time of teachers or pupils. In the present stage of conventional modesty there must be recognized certain limitations in the extent to which the exposure of the person of the pupils will be acceptable to parents or guardians.

It should be distinctly understood that the physical tests advocated may very properly and with advantage be taken as a part of the medical examination of the pupils, but must not in any sense be regarded as a substitute for the complete examination, which involves many important considerations not intended to be included in the brief list advocated.

In the standards submitted, which are based upon the best figures available and are computed by the "generalizing" method, the age represents that of the last birthday.

It must be reemphasized, however, that both the values assigned as norms and those limiting normality must be regarded as tentative. So, in case a child shows extreme variation, i. e., beyond the limits of normality as shown by the standard, in some detail but is within the limits in all other particulars, the question may very properly be raised as to whether normal variation in the detail concerned may not be wider than the figures thus far available have indicated. It is only by repeated checking of temporary standards against many further actual measurements that values deserving of final approval may be secured.

The purpose of this study is to make selections from the widely scattered and varying data derived from relevant investigations, and from these to attempt to establish a minimum list of tentative standards for physical growth and development in the various ages of school life, approximately the ages 6 to 16. It is hoped that such standards may prove of practical value to parents, teachers, physical directors, school nurses, and examining physicians; that they may stimulate interest in the subject; and encourage cooperation in further investigations and experiments with a view to modifying and correcting these tentative standards, of rejecting those which may prove impracticable, and of adding others which may appear significant.

Height

Skeletal growth as measured by height, apart from the variations due to posture, is virtually a bone measurement and appears to be almost entirely independent of unfavorable circumstances such as malnutrition. Among the studies bearing upon this are those of Jackson(75, p. 153) who finds that young albino rats held at constant body weight for considerable periods by under feeding show a normal skeletal growth accompanied by a striking failure of the musculature to increase, which usually at the ages concerned is making rapid gains. This skeletal increase during constant body weight appears to involve ligaments as well as cartillages and bones, and tends to proceed along the lines of normal development as indicated by decrease in water content and by the formation and union of various epiphyses.

Hall(62, Vol. 1, p. 19), after reviewing the work of many investigators, states:

> "Of all single measurements, height is the most valuable. It is easily taken, is relatively constant, and is not liable to much fluctuation. Along with weight it is the truest expression of the energy of growth, the best index of health, and gives a datum from which by the use of current norms and standards, many other data can be approximately inferred. It is, moreover, the most distinctly human dimension as man alone has attained a fully erect attitude."

Rusk(123, p. 25) is authority for another statement of a similar nature, claiming that of the various bodily measurements, height most faithfully indicates general physical development, being less dependent than weight upon variable individual differences. Height measurement indicates that from 6 to 9 years is a period of uniform and rapid development and that at nine irregularities begin to appear.

"There is at this age a retardation with girls, and with boys a more decided retardation occurs at 11 years of age. An acceleration of growth acccompanies the pubertal change, attaining its maximum with girls at 13 and with boys at 15. Girls are shorter than boys except during the years 11 to 14 when they are taller; this is due to the earlier onset of puberty of girls, giving them an accompanying advantage during these years."

Robertson(117, p. 552), basing his conclusions on studies on human subjects, concludes:

"The variability in stature is much less than the variability in weight from which we may infer that as a criterion of abnormalty, the measure of stature is more reliable than that of weight, while as a sensitive indication of the effects of environment or dietetic fluctuations, the measure of weight is to be preferred to that of stature."

By all means the most extensive and representative figures for height of school children are the Boas-Burk tables(31, p. 262), which are derived through merging by approved mathematical methods, the figures of Bowditch, Porter, Boas and others, and include the measurements of 45,151 boys and 43,298 girls in the cities of Boston, St. Louis, Milwaukee, Worcester and Oakland.

As was noted in the introduction, it is essential, in order to allow for individual variations, to provide a standard which includes a reasonable range, on either side of the values representing the average. The usual method of calculating this is by the determination of the quartiles, the 25% and the 75% lines, and regarding these as the limits of normal variation. This has been done for boys by Hastings(70), and since his norms, the 50% line, correspond very closely with the Boas-Burk values, they may be considered as supplementing the above standard tables.

TABLE I

HEIGHT, IN CENTIMETERS, EACH AGE 6 TO 16. (HASTINGS)

	Boys				Girls	
Age	Obs.	25%	50%	75%	Obs.	50%
6	410	107.00	110.67	114.34	352	107.16
7	544	112.19	115.69	119.19	514	114.95
8	565	117.17	121.31	124.85	531	120.16
9	546	122.08	125.86	129.64	534	126.17
10	498	126.79	130.95	135.11	517	131.29
11	660	130.97	134.90	138.83	522	135.16
12	559	135.61	140.29	144.97	526	142.03
13	515	140.28	145.09	149.90	534	148.53
14	435	145.29	151.02	156.75	534	153.17
15	324	151.37	158.18	164.99	459	156.79
16	218	158.26	163.73	169.20	355	157.93

The data for the completion of the table for girls is not at present available.

This table is intended to act as a guide in determining the height development of a pupil. Should his height vary from the norm (50% value) for his age, he may still be within normal limits provided he does not fall outside the extremes (the 25% and the 75% values). Should he vary more than these, however, there is then reason to consider his other aspects of development and find the reason for his deviation from the standard.

One of the most noteworthy facts, now thoroughly established, concerning growth in height is that it is rythmic rather than regular. Data have been collected relative to daily, seasonal and development as well as annual variations.

For recording height, the regulation instrument is the stadiometer, consisting of a horizontal base to which is attached a graduated vertical standard bearing at right angles a sliding arm. The pupil, with shoes removed stands on the base, heels together, knees pressed back, chest lifted, head pushed upward, and chin slightly drawn in. To aid in attaining a vertical position the pupil may be requested to stand so that his heels, sacral and dorsal spine, and back of head are touching the vertical rod. In the absence of this equipment, the heights required may be indicated on any convenient vertical wall or, better still, projecting corner or door post. A book or right-angled piece of cardboard may be suitably graduated for the sliding arm of the stadiometer.

Some observers advocate attempting to secure the normal or habitual standing posture of the pupil, but in the writer's experience, much more uniform results are obtained by having the pupil "stand tall" or "stretch up" as suggested above. This is one test in which encouragement of the pupil to do his best may be advised.

Weight

In weight, as in height, fluctuation rather than regularity is found to obtain. In general the weight development follows that in height, but is much more subject to influence by external forces, and much less determined by heredity. It is on account of this fact that weight is so frequently accepted as an index of condition by both physician and layman, and environment including work, rest, diet, recreation, etc., regulated to produce corrective results. According to Donoldson (52, pp. 49-50) the body from birth to maturity increases in height about 3.37 fold, but the weight increases 20 fold or more.

The fact that weight may be gained or lost readily renders it all the more valuable as an index of the immediate response

of the organism to its environment, as well as an indication of its functioning. Trainers and coaches depend largely upon the daily "weighing in" as a guide to the condition of their men, the commonly accepted standard being that, after the preliminary loss of weight common at the beginning of the season, the weight loss of the daily "work out" should be recovered within 24 hours, otherwise the candidate is approaching "edge" or "staleness" and should have his daily expenditure of energy reduced.

As in the case of height, the accepted standard for weight is the Boas-Burk table(31, p. 263) which shows the average American weight mathematically calculated from the data of about 68,000 children.

Again considering the importance of individual variation, the data worked out by Hastings(70) offer the most convenient reference. In case of weight he gives, in addition to the deviations for boys of different ages, the data from which those for girls may be approximated; there is submitted the following table:

TABLE II

WEIGHT, IN KILOS, FOR EACH AGE OF EACH SEX, 6 TO 16. (HASTINGS)

	Boys				Girls			
Age	Obs.	25%	50%	75%	Obs.	25% *	50%	75% *
6	410	18.06	19.37	20.68	352	17.62	18.50	19.38
7	544	20.30	21.30	22.30	514	19.78	20.70	21.62
8	565	21.28	23.14	25.00	531	21.22	22.17	23.14
9	546	23.11	25.07	27.03	534	23.22	24.90	26.58
10	498	25.74	27.85	29.96	517	25.61	27.16	28.71
11	660	27.49	29.86	32.23	522	27.22	29.00	30.78
12	559	30.14	32.98	35.14	526	31.26	33.06	34.86
13	515	32.15	35.60	39.15	534	35.80	37.94	40.08
14	435	35.00	39.73	44.46	534	39.47	42.92	46.37
15	324	39.93	46.95	53.97	459	42.86	46.71	50.56
16	218	47.60	52.90	58.20	355	46.09	50.38	53.91

* Estimated.

Weight is taken on platform, anthropometric scales of the Buffalo or Fairbanks types, either of which may be graduated in the metric or English units or in both. These scales are provided with two or three bars equipped with sliding, non-removable weights and with balance adjustments. Before each series of weighings, the scales should be balanced so the indicator swings freely between the two limiting bars. As a matter of convenience, the pupils should be weighed wearing ordinary indoor clothing with the exception of shoes which should be removed. On account of the fluctuations due to meals, time of day, etc., record should be made of the hour of the weighing.

Further note of time of year, recent health of pupil, and the like may also have value.

Height and Weight

No matter how favorable may be the inherited tendencies of a child, its environment has much to do with regard to the realization of its potentialities. Though environment cannot always alter the limitations set by inherited factors, it may prevent deteriorating influences from making very serious inroads on the growing individual or interfering with the best attainment of his developmental possibilities.

From the standpoint of hygiene, the most vital consideration of the child's life is nutrition. This, according to Manny(92 p. 123)

"is not merely a matter of food, although that source of growth and energy is the central problem. Nutrition serves as an index of the result of the many strains and stresses that come from adenoids, enlarged tonsils, defective eyesight, and other effects of native disability and unhygienic living."

The standard most widely used for judging nutrition is known as the Dunfermline scale. It recognizes 4 groups, as follows:

1. "Excellent" represents the nutrition of a healthy child of good social standing.
2. "Good" is applied to those whose nutritive condition falls just short of "Excellent."
3. "Requiring supervision" describes children who are on the borderline of serious impairment.
4 "Requiring medical treatment" indicates that nutrition is seriously impaired.

In spite of the fact that these divisions do not seem to be very clearly defined, experience with the scale shows a surprisingly small variation among different examiners working on the same group of children.

Holt(73) has considered the question of some definite and measurable index of nutrition, and finds that weight in relation to age is not of greatest value, but that weight related to height is most significant. According to him the weight-height index would fix the child's status in nutrition,while annual increase in height would indicate his progress in growth, a question entirely different from that of nutrition.

The above conclusion is in accord with the suggestions of many investigators who have made similar attempts in the past.

Bowditch in 1877(22, p. 301) called attention to the importance of ascertaining the relation of height and weight in growing children, which might be expressed as a quotient.

Stephenson(128), bases results upon the figures of Bowditch for American and Anthropological Committee of the British Association, for English children. He has worked out a series of tables giving the standard weight, in pounds, for each inch in height, for boys and girls of each age from 6 to 18 years. These tables bear a resemblance to those prepared by Dr. Thomas D. Wood, published and so widely distributed by the United States Bureau of Education during the last few years.

The noted variations in the height-weight relation and in the relative development of different parts of the body, at each age, has raised the question of physical "types."

In 1910 De Giovanni(50, 51) published the results of his investigations on proportions and types. Montessori(97) in 1913 published extensive figures concerning human proportions and laid great emphasis upon the relation of length of trunk to that of limbs. Bryant(26, 27) stressed the importance of a knowledge and appreciation of the proportions of the trunk in relation to efficiency.

Goldthwaite(60) has given the most complete description of the neutral, the carnivorous or "lean" type and the herbivorous or "stout" type. His claim is that on the basis of the general proportions of the trunk may be inferred many other significant details of structure and function, such as length of intestine, shape and number of vertebrae and ribs, shape of stomach and appendix, etc. In addition to these non-visible features he shows the correlation between type, and quality of skin, pilosity, shape of feet, and other important organs. But most important of all is the demonstrated relation of type to health and disease, to occupation, and to biological principles of the development of the race.

Lewis(85) has made a study of adolescents on the basis of structural types and finds a decided preponderance of the carnivorous or "lanky" type, while the herbivorous exceeds the neutral type which constitutes only about 12% of the entire group examined. This shows a strong tendency towards the decided types and is due, Bryant claims(28), to diet, the key to the control of type and consequently to the diseases to which each type is liable.

The significance of these types from the standpoints of health, interests, capabilities and education is doubtless great, but the details of the proportions which would throw an individual of a given sex and at a given age out of the neutral and into the "stout" or the "lean" groups have not been so determined as to be generally accepted.

Taylor(132) has grouped boys into 5 rather than 3 types and has given the figures distinguishing the groups from each other.

Using height as the standard, he relates other measurements to it and only incidentally compares the measurements as a group with age.

Lowman(86, pp. 693-5) has used the material outlined by Goldthwaite and added from his own findings, giving a popular and significant outline of types and their features.

Emerson(54a), as the result of his nutrition clinics in New York, Boston and other cities is satisfied that at least 20% of the pupils in attendance at the public schools are under nourished. In order to offer an objective standard by which nutrition may be readily judged, he has published a height-weight table and has given the variations from the standard regarded as indicative of under nourishment. This table is adapted from the figures given by Holt(73) for the younger children and from the Boas-Burk tables for pupils of school age. Since the present interest is with the latter group only, his table is quoted in part.

TABLE III

EMERSON'S NUTRITION STANDARDS

Height Inches	Boys			Girls		
	Aver. Wt. for Ht. Lbs.	7% Under Wt. Lbs.	10 % Under Wt. Lbs.	Aver. Wt. for Ht. Ins.	7 % Under Wt. Lbs.	10 % Under Wt. Lbs.
40	38.1	35.4	34.3	37.4	34.8	33.7
41	39.8	37.0	35.8	39.2	36.6	35.3
42	41.7	38.8	37.5	41.2	28.3	37.1
43	43.5	40.5	39.2	43.1	40.1	38.8
44	45.4	42.2	40.9	44.8	41.7	40.3
45	47.1	43.8	42.2	46.3	43.1	41.7
46	49.5	46.0	44.6	48.5	54.1	43.7
47	51.4	47.8	46.3	50.9	47.3	45.8
48	53.0	49.3	47.7	53.3	49.6	48.0
49	55.4	51.5	49.9	55.3	51.9	50.2
50	59.6	55.4	53.6	58.3	54.2	52.5
51	62.5	58.1	56.3	61.1	56.8	55.0
52	65.8	61.1	59.2	63.8	59.3	57.4
53	68.9	64.1	62.0	66.8	62.1	60.1
54	72.0	67.0	64.8	70.3	65.4	63.3
55	75.4	70.1	67.9	74.5	69.3	67.1
56	79.2	73.7	71.3	78.4	72.9	70.6
57	82.2	77.0	74.5	82.5	75.7	74.3
58	87.0	80.9	78.3	86.6	80.5	77.9
59	91.1	84.7	82.0	91.1	84.7	82.0
60	95.2	88.5	85.7	96.7	89.9	87.0
61	99.3	92.3	89.4	102.5	95.3	92.2
62	103.8	96.5	93.4	110.5	102.7	99.4
63	108.0	100.4	97.2	118.0	109.7	106.2
64	114.7	106.7	103.2	123.0	114.4	110.7
65	121.8	113.3	109.6	130.0	120.9	117.0
66	127.8	118.9	115.0	137.0	127.4	123.3
67	132.6	123.3	119.3	143.0	133.0	128.7
68	138.9	129.2	125.0	146.9	136.6	132.2

In discussing the above table, Emerson states(54a) that:

"All children who are habitually as much as seven per cent under weight for their height are malnourished. This degree of under weight means that the children are at least *a whole year below the normal standard which they ought to have attained.* They are not only under weight, but under their normal height also."

Emerson does not entirely disregard height in relation to age. A letter from his clinic says:

"We make it a rule to use the weight-height ratio for the purpose of selecting that very large group of malnourished children most urgently in need of attention, and then depend upon individual diagnosis to identify borderline cases not reached by the general rule. Naturally, any child who is clearly below the height and weight measurements usual at his age, receives special consideration, even though his ratio may be normal. In such a case an actual condition of good health must be proved before it is fair to assume that he is doing as well as is possible for him to do."

This latter statement is important from the fact that arrest of height growth due to under nutrition is rapidly overcome when such stunted children are placed under proper conditions, for they soon prove that they have a capacity for growth in both height and weight not heretofore realized.

Osborne and Mendel(100, 101, 102) have given ample experimental evidence of the remarkable power of young animals to resume growth, at an accelerated rate, after long-continued retardation due to unfavorable conditions, e. g., unsuitable diet.

Retan(114) has given evidence, in graphic form, of the unreliability of using weight in relation to age as a standard of nutrition, and is satisfied that the weight-height relation affords a suitable index.

Teeth

Among the reasons for special attention to the time of eruption of permanent teeth, as an index of physical development, maye be noted the following:

1. The first permanent tooth to erupt is the first molar, which is the sixth tooth from the middle line of the face, and makes its appearance normally by the time the child is six years of age. It is, in consequence, sometimes called the six-year molar, and, on account of the fact that it erupts about the time the child enters school, it is a most convenient sign post of physical development. All too frequently, this tooth is regarded by child, teacher and parents as one of the temporary set, and since it erupts when the milk teeth are about to be shed, its

life is supposed to be of but short duration, and in consequence it seldom receives the attention and care which its position in the arch demands.

The statement of Angle(1, p. 302) is that in function and influence some teeth are of greater importance than others, the most important of all being the first permanent molars for the following reasons:

(1) "They are the largest and firmest in their attachments.
(2) "They have the most important location in the arches.
(3) "Their length determines the separation of jaws, and length of bite, thus contributing to facial proportions.
(4) "They are first in position, and influence other tooth positions.
(5) "They are most constant in time of eruption, and in the assumption of normal positions."

2 Tooth eruption continues more or less regularly throughout school life, thus affording a practically constant indication of the rate of physical development in the individual pupil.

3. There is not required for the recording of the eruption of the teeth any elaborate equipment, nor is there great likelihood of error because of personal equation. Certain teeth either are or are not present, and if present may be seen, identified and counted. This test is therefore one of the most definite of any in use or in fact conceivable.

4. The teeth have a peculiar relation to nutrition. On the one hand the time of their eruption, their shape, condition, etc., is an indication of the pupil's nourishment up to the time of examination; and, on the other hand, the number, condition and arrangement with regard to occlusion is very definitely related to food mastication and consequently to subsequent digestion and assimilation. This latter aspect has received recent emphasis from the number of rejections of recruits on account of failure to measure up to the Government requirement in this particular.

5. There seems to be adequate evidence of the value of the age at which teeth erupt as a factor indicating development. Mackenzie(91, pp. 255-65) states that the number of teeth present at any given age is of prime importance as a test of development. Bean(12, p. 612), concludes that:

"the teeth are more convenient and more exact as a means of determining the physiological standard than stature or weight or growth of bones or secondary sexual characteristics, etc., and they may be of greater value than any other means that can be utilized."

Beik(14, p. 203), after careful investigation, is entirely satisfied that:

"The state of advancement reached in dentition is a good indication of the stage of progress which a child has reached in its total physical development."

Bean(12, p. 601) has prepared a standard table for norms of teeth eruption of American children, but since he has not offered figures indicating normal variability, the table prepared by Woodrow(145, p. 103) which agrees closely with Bean's is selected. These figures are based mainly on the work of James and Pitts(76) who investigated 4,850 English children of school age.

TABLE IV

SHOWING THE AGES AT WHICH 50%, 25%, AND 75% OF CHILDREN NORMALLY HAVE ERUPTED THE TEETH INDICATED. (WOODROW)

Name of Tooth	Present in 50% of Children	Present in 25% of Children	Present in 75% of Children
Lower First Molar.....	6 Yrs. 0 Mos.	5 Yrs. 6 Mos.	6 Yrs. 6 Mos.
Upper First Molar.....	6 " 3 "	5 " 9 "	6 " 6 "
Lower Median Incisor..	6 " 6 "	6 " 0 "	7 " 0 "
Upper Median Incisor..	7 " 6 "	7 " 0 "	8 " 3 "
Lower Lateral Incisor..	7 " 6 "	7 " 0 "	8 " 6 "
Upper Lateral Incisor..	8 " 6 "	8 " 0 "	9 " 3 "
Upper First Premolar...	10 " 0 "	8 " 9 "	10 " 9 "
Lower First Premolar...	10 " 6 "	9 " 6 "	11 " 9 "
Lower Canines.....	10 " 6 "	9 " 9 "	12 " 3 "
Upper Second Premolars	11 " 0 "	9 " 9 "	12 " 0 "
Lower Second Premolars	11 " 6 "	10 " 3 "	12 " 6 "
Upper Canines.....	11 " 9 "	10 " 9 "	12 " 9 "
Lower Second Molars..	11 " 9 "	10 " 9 "	14 " 0 "
Upper Second Molars..	12 " 6 "	11 " 6 "	14 " 3 "
Third Molars.....	14th to 24th Year		

The range in the above table is sufficiently wide to allow not only for variation due to sex but also for those arising from other normal influences.

Despite the fact that several authorities, of whom some have been quoted, are positive as to the uniformity of the age of tooth eruption, it seems necessary to add that, as in the case of other developmental aspects, undue emphasis must not be placed upon this single index by itself. So many are the factors which may influence the time of eruption that a too rigid application of this one standard, without relation to others, might easily result in entirely erroneous conclusions. This is particularly true with regard to those areas of the dental arch subject to the greatest variation, viz., the region of the upper lateral incisors, the lower second bicuspids, and the wisdom teeth or third molars.

Motor Development

One of the most significant of all possible tests would be one showing the rate of progress in neuro-muscular coordination. Experimenters have virtually all come to the adoption of the speed of tapping as the most representative of the practicable tests of motor development. It is known that at birth the child has control of but a few muscle groups—those connected with sucking and grasping being the conspicuous exceptions. With the growth and elaboration of the nervous system comes that coordination of the neuro-muscular mechanism so well traced by Burk(30).

Hall(62, p. 142) regards "the greatest number of taps that can be made in a given brief time interval as an important determination for the development of accessory muscular control" and as a "very important measure as a factor of motor ability."

The complete laboratory outfit is rather elaborate, consisting of the tapping board, 50 x 10 cm., with brass plates 10 cm. square on either end; tapping stylus with flexible connecting wire; kymograph with its essential accompaniments; and a stop watch. This may be much simplified by the substitution of an electric counter which will record the number of taps as accurately as the kymograph.

Franz, however, is sponsor for a method of testing motor development which does not involve expenditure for equipment. He explains it somewhat as follows(56, pp. 45-46): A very simple and inexpensive method of testing this type of voluntary control is to provide the pupil with paper and pencil, and have him make a series of dots as rapidly as possible for the required interval of time. The time selected is frequently 30 seconds and may be kept by a stop watch or, for practical purposes, by a watch or clock equipped with a hand recording seconds.

The technique of taking the test is simple. Seat the pupil in a chair of suitable height with his side (right then left) towards the desk or table, so that the forearm will rest comfortably upon the support. The tapping is done by a movement from the wrist with the pencil held vertically; it begins and ends on signal and is continued for 30 seconds. Record is made of the performance of the right hand, then of the left.

Experimental data are not abundant upon which to base even tentative norms. The results obtained by Smedley(127, p. 41) and by Pyle(113, p. 25) constitute the most extensive and are given below.

TABLE V

RATE OF TAPPING, 30 SECONDS, BOYS. (SMEDLEY AND PYLE)

	Smedley			Pyle		
Ages	Obs.	Right	Left	Obs.	Right	Left
6	..	...	...	62	121	107
7	..	...	...	61	129	111
8	31	147	117	76	136	111
9	60	151	127	76	144	123
10	47	161	132	70	152	131
11	49	169	141	84	163	136
12	44	170	145	74	168	141
13	50	184	156	82	175	150
14	40	184	155	75	177	154
15	37	191	169	85	188	166
16	21	196	170	51	190	168

TABLE VI

RATE OF TAPPING, 30 SECONDS, GIRLS. (SMEDLEY AND PYLE)

	Smedley			Pyle		
Ages	Obs.	Right	Left	Obs.	Right	Left
6	..	...	...	66	121	103
7	..	...	...	59	132	112
8	31	146	117	63	135	118
9	44	149	118	70	148	128
10	48	157	129	76	154	133
11	48	169	139	75	163	141
12	50	169	140	86	169	148
13	45	178	153	93	172	151
14	67	181	157	63	183	158
15	48	181	159	94	185	159
16	50	187	167	94	187	163

NOTE.—In Tables 13 and 14 the number of cases is not exact for Pyle's observations, since he had not always the same number for each hand; those given are for the right hand test.

In comparing the figures of Smedley and Pyle as given above it will be noticed that Smedley does not give the data for the ages 6 and 7; that Smedley's figures are higher than Pyle's except, in the main, those for girls where in some cases Pyle's results are greater; and that the number of cases on which Pyle's norms are based is greater than Smedley's.

Both investigator's, however, report less than 100 cases in each age so that it would appear that these norms are based on data insufficient to justify their final acceptance. Much further work should be done in this test not only that norms

may be established but also that the range of deviation may be secured and thus the zones of normality determined.

Lung Capacity

The terms lung capacity, breathing capacity and vital capacity have been used to designate the volumetric difference between the lung content at forced inspiration and at forced expiration. It might with more propriety be termed differential lung capacity or respiratory capacity, since even after forced expiration, the lungs are by no means collapsed but contain a residuum of air roughly estimated for the adult at 1,640 cubic centimeters (100 cubic inches).

This test is of exceptional value in that it indicates both development and functional power. Not only is there given an idea of the size of the thoracic cavity but more important still of the control or mobility of the chest. Chest girth is sometimes taken as an index of lung capacity. Military requirements are frequently based on a stated expansion for a given height. This means that the difference between the chest girth fully expanded and forcibly deflated must measure a certain number of inches or centimeters for each respective inch or centimeter of total stature.

All tape and caliper chest measures, however, are partial in that they cannot record the enlargement of the thorax along the vertical axis, produced by the movement of the diaphragm, the chief muscle of respiration. These external measures are of great significance from the standpoint of diagnosis, but involve the stripping of the child to the waist, a procedure not yet common except in medical examinations.

But the volumetric displacement recorded by the wet spirometer, includes the results of all the factors contributing to the change in intra-thoracic capacity, and in consequence from the standpoint of a functional test is much superior to any measurement which may be made upon the surface.

In making this test, the pupil is asked to inhale as deeply as possible, take the mouthpiece in his mouth and exhale steadily and continuously through it into the instrument, forcing out of the lungs as much air as possible. Record the reading of the indicator at the highest point of each of the two or three trials allowed and credit the pupil with the highest figure secured. In restoring the spirometer to its initial starting position, care should be taken to remove the stopper and to press the inverted cylinder down steadily but *slowly* to its original position, replacing the stopper. Pupils should be advised to grasp the mouth piece firmly with the lips, that no air escape around it and so lower the record. Exhalation should be

steady and not forced except during the latter part. Hygienic precautions in connection with assuring a sanitary condition of the mouth pieces demand that either the glass mouth pieces be thoroughly sterilized after use or, preferably, that wooden or paper mouth pieces be provided and discarded after use by one pupil; the expense is negligible. If necessary, pupils may be allowed to occlude the nostrils by pinching the nose between thumb and finger.

The norms and deviations from the standards are worked out in detail for boys by Hastings who also gives the figures from which those for the girls may be estimated approximately.

TABLE VII

LUNG CAPACITY, IN CUBIC CENTIMETERS, FOR EACH AGE (HASTINGS)

	Boys			Girls		
Age	25%	50%	75%	25% *	50%	75% *
6	560	830	1,000	580	710	840
7	810	990	1,170	710	830	950
8	950	1,150	1,350	830	990	1,150
9	1,140	1,230	1,520	980	1,140	1,300
10	1,250	1,480	1,520	1,130	1,270	1,510
11	1,450	1,660	1,870	1,140	1,350	1,560
12	1,610	1,830	2,050	1,300	1,540	1,780
13	1,770	2,030	2,290	1,560	1,730	1,900
14	1,950	2,300	2,650	1,620	1,850	2,080
15	2,210	2,640	3,070	1,720	2,020	2,300
16	2,640	3,140	3,640	1,880	2,140	2,380

* Approximated

FOREARM STRENGTH

The finger flexors of the forearm, those used in closing the fingers as in giving a grip, are probably the most representative group of muscles in the young since they are in almost constant use in the routine of daily life. No matter at what employment or amusemnet one may be engaged there is necessarily much holding, handling, grasping, etc., which brings into functional activity this muscle group. Moreover, these muscles are of fair size, thereby giving a much more reliable index of muscular power than would a smaller group such as the flexors of a single finger which are often used in ergograph tests. According to Meyers(98) the child is born with an automatic grasping mechanism which "goes off" when stimulus is applied to the proper place, so that practice in co-ordinating the muscles involved is begun much earlier than in others producing movements of equal complexity. The actual taking of the test is comparatively simple, and with the adjustable Smedley dynamometer is reasonably accurate.

Measurement in millimeters, is first taken from the point where the pupil's thumb joins the hand, to the tips of the fingers. The manuometer is adjusted, by whirling the inner stirrup until the scale on the outer stirrup indicates one-half the distance above secured. Record this distance and set the clutch to prevent twisting of the inner stirrup during the test. Before each test set the indicator on the dial at zero. Have the pupil exert maximum grip, grasping the inner stirrup at the centre rather than toward either side. See that no part of the instrument touches any object other than the hand gripping it. Test the hands alternately, right and left, two or three times each, and select for permanent record the best performance for each hand.

TABLE VIII

STANDARDS OF FOREARM STRENGTH IN KILOS. (HASTINGS)

Boys

		Right Hand			Left Hand		
Age	Obs.	25%	50%	75%	25%	50%	75%
6	410	5.08	6.98	8.88	3.90	5.70	7.50
7	544	7.59	9.18	10.77	6.62	8.53	10.44
8	565	8.66	10.63	12.00	7.99	9.53	11.07
9	546	10.94	13.14	15.34	9.83	11.57	13.71
10	498	12.24	14.74	17.24	11.73	14.05	16.39
11	660	15.64	18.02	20.40	13.81	16.11	18.41
12	559	16.99	19.68	22.37	15.54	18.44	21.34
13	515	18.90	22.59	26.28	17.76	20.49	23.22
14	435	21.25	25.37	29.19	18.91	23.05	29.19
15	324	22.61	28.85	35.09	20.11	24.68	29.25
16	218	25.66	33.31	40.96	22.76	29.64	36.52

TABLE IX

STANDARDS OF FOREARM STRENGTH IN KILOS. (HASTINGS)

Girls

		Right Hand			Left Hand		
Age	Obs.	25% ⁂	50%	75% ⁂	25% ⁂	50%	75% ⁂
6	183	4.27	5.17	6.07	4.13	4.83	5.53
7	514	5.58	7.48	9.38	4.80	6.60	8.40
8	521	7.96	9.26	10.56	7.60	8.81	10.01
9	534	8.26	10.06	11.86	7.98	9.68	11.38
10	517	10.78	12.98	15.18	9.73	11.63	13.33
11	522	12.01	14.11	16.31	12.52	14.42	16.32
12	526	13.74	16.04	18.34	12.53	14.55	17.95
13	534	15.82	18.52	21.22	15.06	17.66	20.26
14	534	17.93	21.73	25.53	16.31	19.51	22.71
15	459	20.62	24.44	28.24	19.64	22.94	26.24
16	355	20.03	24.13	28.23	18.95	22.95	26.95

⁂ Approximated.

Pubescence

As a result of comparatively recent scientific study of individual human development, especially from the genetic point of view, there has arisen an exceptional interest in the significance of the truly remarkable transformations, both physical and mental, which are related to pubescence.

Hall(62, p. 128) briefly summarizes the relation of education to adolescence as follows:

> "It is the age of reconstruction, when new determinants come to the front and also the point of departure for new lines of development. It is the age too when, if ever, previous tendencies to abnormality may be overcome both by nature and by treatment. The law of nascent periods or the age curve of growth of each organ or faculty, is one of the first desiderata of genetic psychology; how to apply it, by what means and to what degree to stimulate each part in its stage of most and least rapid growth, and how to apportion training of mind and body between developing the powers that excel to a degree of specialized culture that corresponds to their hereditary possibilities, or educating the weakest parts and powers in order to improve proportion and symmetry, is one of the chief problems of individual pedagogy."

The original and significant work of Crampton(44) has established and to a degree popularized a method for determining from external signs the progress of this notable aspect of Physiological development, and has compared it with chronological age.

This marked transition from the asexual to the sexual life occurs at various periods with different individuals, usually between 12 and 15 years of age, but whenever it does develop the changes are profound. Crampton(45, p. 228) thus describes it: "In the short space of 6 months the child becomes a man or woman, and the process is fraught with the dangers and turmoil of a new birth. There is an outburst of physical growth, 4 or 5 inches are added to the height, 30 or 40 pounds to the weight, and the strength may be doubled in a short space of time."

The relationship of this physiological change to age of boys, as ascertained by Crampton from the examination of 3,835 boys in New York City high schools is given as follows(41, p. 232):

TABLE X

PERCENTAGE OF EACH AGE IN EACH PHYSIOLOGICAL GROUP

Age in Years	Physiological Age Groups		
	Immature	Maturing	Mature
12.50 to 13.00	69%	25%	6%
13.00 to 13.50	55%	26%	18%
13.50 to 14.00	41%	28%	31%
14.00 to 14.50	26%	28%	46%
14.50 to 15.00	15%	24%	60%
15.00 to 15.50	9%	20%	70%
15.50 to 16.00	5%	10%	85%
16.00 to 16.50	2%	4%	93%

Dr. Wm. Burdick, Director of the Public Athletic League of Baltimore, has had observations made on girls, using as the index of pubescence, subcutaneous fat, axillary hair, appearance of breasts, and distinction between waist and hips, together with the personal statement of the girls as to the time of their development.

Part of the results of his studies may be found in the accompanying table, which is based on examinations by Dr. Mary A. Hodge, of more than 3,000 girls. The figures refer to the relationship of pubescence to age and include the ages 6 to 16 to coincide with the general ages considered in this treatment.

Crampton(41, pp. 232-4) has shown the marked relationship of the pubertal development of boys, ages 12 to 16, to height, weight, strength, etc., and has established the significance of this physiological functional development.

Educators have not realized to the full the importance of physiological age, especially in its bearing upon mental and social development. This lack of appreciation is evidenced by the fact that during the dozen years since Crampton made his masterly and widely circulated presentation of its claims, there are comparatively few educational institutions into which classification on this basis has been introduced.

Among the difficulties most frequently urged against the introduction of this basis of classification, may be noted the following: For half or more of the school life of the child, this basis of grouping has no significance, since it does not apply until signs of maturity are manifested.

The practical problem of continuous regrouping during more than 5 years, required for the entire mass of students to pass from the immature to the adolescent stage, seems to be more than the average principal or superintendent is willing to undertake. Still, it has been done. Principal Louis Marks, Public School No. 54, Manhattan, New York City, writes under date of May 3, 1920:

TABLE XI

MATURITY OF GIRLS AROUND BALTIMORE

	Prepubescent		Pubescent		Adolescent	
Age	Obs.	%	Obs.	%	Obs.	%
6	14	100.0	..	....	...	....
6.5	23	100.0	..	....	...	....
7	33	100.0	..	....	...	....
7.5	46	100.0	..	....	...	....
8	60	100.0	..	....	...	....
8.5	54	100.0	..	....	...	....
9	79	100.0	..	....	...	....
9.5	108	99.0	1	1.0	...	....
10	112	100.0	0	0.0	...	....
10.5	127	96.2	4	3.0	1	0.7
11	114	92.6	9	7.3	0	0.0
11.5	103	78.6	25	19.0	3	2.2
12	90	66.1	39	28.6	7	5.1
12.5	88	57.5	45	29.4	20	13.0
13	61	37.8	61	37.8	39	24.2
13.5	38	23.7	49	30.6	73	45.6
14	24	13.4	51	28.7	103	57.8
14.5	7	4.7	29	19.7	111	75.5
15	4	2.7	22	15.1	119	82.0
15.5	2	1.3	11	7.1	141	91.4
16	2	1.4	6	4.2	133	94.3
16.5	0	0.0	4	3.0	126	96.9
17	1	1.1	..	....	98	97.9
17.5	1	1.1	..	....	87	98.8
18	1	0.1	..	....	658	99.7
Total	1202		356		1719	
			Grand Total.....			3277

"In answer to your request of April 28th, I beg to state that we have continued the system of classification of pupils on the basis of Dr. Crampton's Physiological Age ever since it was introduced some seven years ago. We have every reason for maintaining this grouping of the boys in the upper grades of our school. The teachers find this arrangement far more helpful than the old promiscuous grouping. The emotional and social factors are the predominant reasons for continuing this plan."

In physical contests such as athletics, in playgrounds, public and Sunday School athletic leagues, etc., a division of contestants upon the physiological age basis, has been found to work out satisfactorily, subdivisions on some other basis, e. g., weight being made within each of these large groups when necessary.

An attempt has been made to correlate the three physiological groups of the ages 12 to 16 with the 25%, 50% and 75% values of the same chronological age. Since Crampton's tables of height, weight and grip show a distribution within each age,

corresponding in a measure with the percentile values, some are satisfied that the percentile grouping within each chronological age is adequate. Foster(55, p. 87), speaking of classes grouped on a physiological basis, rather supports this view with regard to height.

"There is some overlapping of height in the different grades of pubescence, but the relationship is so close between height and pubescence that it might seem to a person who had a view of the different classes at the same time as if the classification had been made according to height. All the smallest boys are found in the first grades, and all the largest in the last grades, although in the physical examination not the slightest attention was paid to the boy's weight when the degree of pubescence was noted."

From the biological point of view, however, the tendency seems to be to regard sexual development as one, and in many respects the most important, of the physical manifestations in man of the great fundamental vital principle characterizing all organisms; the common factor of which growth of all the structures and maturing of all the functions are but different aspects.

Of the various physical sign posts considered, pubescence seems to be related more definitely than any of the others, to the mental and social aspects of the pupil's development, so has additional claim to consideration, but this phase is outside the scope of the present inquiry.

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